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Measuring Adult Mortality in Developing Countries

A Review and Assessment of Methods

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In countries where full death registration is a distant goal, the best way to collect data on adult mortality is probably to combine sample community-based health reporting systems and single-round surveys in which respondents are asked about the survival of various relatives — including parents, first spouses, and siblings.

Reliable information about adult mortality — ideally, by age and cause for population subgroups — is important for population and health care planning and as an indicator of changes in human welfare. In most developing countries, data collection methods in the civil registration system and health services are woefully inadequate and methods for adjusting them apply only at the national level.

In the many developing countries where deaths are not fully registered, the best way to collect data on adult mortality is probably to combine sample community-based health reporting systems and single-round surveys in which respondents are asked about the survival of various relatives, including parents, first spouses, and siblings.

The authors argue that a few reliable indicators that cover the whole population are not only more affordable but more useful for health planning than a mass of information of doubtful accuracy and completeness.

One should not make inferences about adult mortality by extrapolating from information on child deaths. Only genuine measures of adult mortality are useful for planning. Several approaches — active sample registration systems, multi-round demographic surveys, sentinel site reporting, and demographic surveillance systems — have been fairly successful but expensive. Questions put to household heads about recent deaths in the household seldom yield useful data and should not be used in their present form.

Demographic research shows that age patterns of mortality are similar in all popula-

tions, so it is possible to estimate mortality rates with reasonable reliability from simple data on the proportions of surviving relatives reported by survey respondents. More research is needed to determine whether indices of mortality by cause can be similarly inferred from general proportionate measures of death from particular causes. Single-round surveys asking about family survivors have not always worked well, but they often yield good estimates of adult mortality at relatively low cost, are efficient in sample size, and based on straightforward questions about the respondents' lifetime experience.

The method's main limitation is that it provides rather broad, nonspecific measures of mortality — but these are adequate for allocation of resources, which is likely to be affected only by large differences. (Methods to elicit more specific information are still in the experimental stage.)

Certain questions need further investigation:

- Can additional information important for health planning be gathered in the context of surveys designed to measure levels, trends, and differentials in adult mortality?
- Can the indirect questions used in single-round surveys be used to investigate causes of death, on the one hand, and some of the social and economic consequences of adult deaths on the other?
- Can the measurement of adult mortality be integrated with efforts to improve our understanding of ill health in the surviving adult population?

This paper is a product of the Population, Health, and Nutrition Division, Population and Human Resources Department. Copies are available free from the World Bank, 1818 H Street NW, Washington DC 20433. Please contact Sonia Ainsworth, room S6-065, extension 31091 (58 pages with figures).

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MEASURING ADULT MORTALITY IN DEVELOPING COUNTRIES:
A REVIEW AND ASSESSMENT OF METHODS

INTRODUCTION.

This paper reviews experience of the measurement of adult mortality in developing countries, assesses the performance of existing approaches and suggests some possible routes to the development of improved methods. The need to obtain better information on adult mortality is indisputable. Premature deaths in adulthood are common in developing countries. In some, the probability of dying before age 60, having survived childhood, is at least as high as the probability of dying in the first few years of life. The death of a young and productive adult with dependents has major social and economic consequences. More plentiful and accurate population-based measures of the level, causes and social and economic consequences of mortality in adulthood could contribute to its amelioration in several ways. Firstly, such information can be used to quantify the extent of the public health problem represented by adult mortality, making it possible to assess its priority in the allocation of resources. Secondly, better information could be used to clarify the determinants of adult mortality and thereby to identify points for intervention. Thirdly, quantitative measures are needed in order to monitor and evaluate the effectiveness of programmes intended to reduce adult mortality.

The assumptions and limitations of methodologies and the corresponding measures that can be used to assess priorities and determine programme effectiveness are not the concern of this paper. It should be noted, though, that even the use of apparently uncontroversial synthetic measures of mortality, such as life expectancy, raises complex issues. Such indicators entail implicit assumptions about the social and economic costs to be assigned to deaths at different ages. In addition, life expectancy is an inappropriate measure of programme impact as it assumes that those individuals whose lives are saved this year will continue to benefit from lower mortality risks for the rest of their lives (Ewbank, 1984). Whatever

indices of mortality are used, aggregate measures can conflate quite different problems. Some factors that affect mortality may lead to a small increase in the risk of death for a large number of people, others to a large increase in the risk of death for the disadvantaged minority. Both of these health outcomes may have similar implications for overall mortality but are they equivalent? Even the type of study required to determine health priorities will depend on whether it is more appropriate to target diseases, interventions, areas or social groups? The first strategy suggests the importance of obtaining cause-specific measures of mortality, the second emphasizes the importance of impact evaluations, while the latter lead naturally to the study of mortality differentials.

Rather than discussing the uses of mortality data in the allocation of resources to reduce ill-health, we focus on the measurement of mortality in countries with unsophisticated statistical information systems. Mortality rates by age, sex and cause for sub-groups of the population are required to calculate most indices of need or of programme impact. Unfortunately, most developing countries do not possess the resources required to collect and process such detailed data using the methods currently available. The body of the paper therefore considers the information developing countries can aim to collect on adult mortality. In the conclusions we return briefly to a consideration of the value of this information for setting priorities and for planning and evaluating interventions to reduce adult mortality.

The development, assessment and refinement of methods for collecting and analyzing information on mortality in developing countries is an active and ongoing field of research that has generated a large literature. One important series of reports is that produced by the International Program of Laboratories for Population Statistics at the University of North Carolina during the 1970s. More recently, two volumes of papers that review much of the field have been published under the sponsorship of the United Nations (UN) and the International Union for the Scientific Study of Population (IUSSP) respectively (UN, 1984; Vallin et al., 1984). A wide range of publications with a more specific focus have been produced by various international agencies; specialist organizations, such as the International Institute for Vital Registration and Statistics; international programmes of survey research, such as the World Fertility Survey (WFS); and independent

researchers. Many of the findings from these activities are encapsulated in a range of handbooks and manuals produced by the UN agencies (eg. UN, 1973; 1983, WHO, 1977).

While much of the literature on methods for collecting and analyzing mortality data is avowedly general in scope, in practice it tends to concentrate on child mortality. This reflects several factors, including the relative ease with which child mortality can be measured using survey data, the huge number of preventable deaths that occur in the first few years of life and the importance accorded to the infant mortality rate as a general indicator of social and economic development. This review has the opposite emphasis: it concerns adults. Within the field of adult mortality we further concentrate on areas where we perceive opportunities for methodological advance. In particular, we consider possible ways of obtaining more specific measures of adult mortality, whether this specificity is defined by age, cause or the reference period to which the measures apply.

It is worth mentioning briefly in this introductory section some of the general issues that make the study of adult mortality more complex than that of child mortality. In broad terms, adult mortality rates are an order of magnitude lower than those of children. Adult deaths are relatively rare events. To obtain reliable measures of adult mortality requires data either on a large sample of people or on events occurring during a long reference period. A second issue that arises is that it is difficult to identify an appropriate informant who can provide reliable information about deceased adults. Accurate data on child mortality can usually be collected from the children's parents and, in particular, their mothers. In addition, the characteristics of parents are among the more important determinants of the risk of dying in childhood. Since there is no single, universally suitable informant to provide data about adult deaths, problems of undercounting and multiple reporting are common. Moreover, it is often unreasonable to use the social and economic characteristics of the respondent as a proxy for those of the dead person. Thirdly, while the vast majority of the child deaths in the developing countries arise from a limited number of infectious diseases, the causes of death in adulthood may be more diverse and more difficult to diagnose. Finally, it is normally possible to obtain usable information on the ages of children and their ages at death. Accurate information on adult

ages is more difficult to collect. Older people are less likely to have birth certificates than the young. Levels of education decline rapidly with age in most developing countries. Moreover, even if the person who died knew their own age, the informant who reports their death may not. Thus it is difficult to obtain reliable data that can be used to study age-specific mortality in developing countries. Ages tend to be exaggerated and ages at death are exaggerated even more.

The following sections of the paper review the various methods which can be used to measure adult mortality in developing countries. They are grouped under two major headings. The first group of methods yield direct measures of adult mortality. It comprises all approaches in which the information collected and analyzed refers to the deceased individual. These include the traditional sources of data on adult deaths such as vital registration systems, health services statistics and multi-round surveys. The second set of methods yield indirect measures of adult mortality. One subset of these methods involves the analysis of census age distributions. In the other, the unit of analysis is not the deceased person but a clearly defined category of their relatives. To clarify the structure of the paper, a diagrammatic representation of the classification of methods of measurement is presented in figure 1. For each of the approaches to the measurement of adult mortality considered, we outline its basis and rationale, review experience of its application and offer an assessment. The final section of the report assesses the utility of the different methods and identifies both the main gaps in the information collected and some of the opportunities for improvement.

DIRECT MEASURES OF ADULT MORTALITY

I. NATURE OF THE INFORMATION.

Direct methods and measures of mortality are often regarded as the conventional or classical approach to demographic estimation, largely because they form the basis of the statistical systems of developed countries. The direct approach has thus long been seen as a goal to be achieved by the poorer nations. While the wisdom of this view is now challenged (Hill, 1984a) most

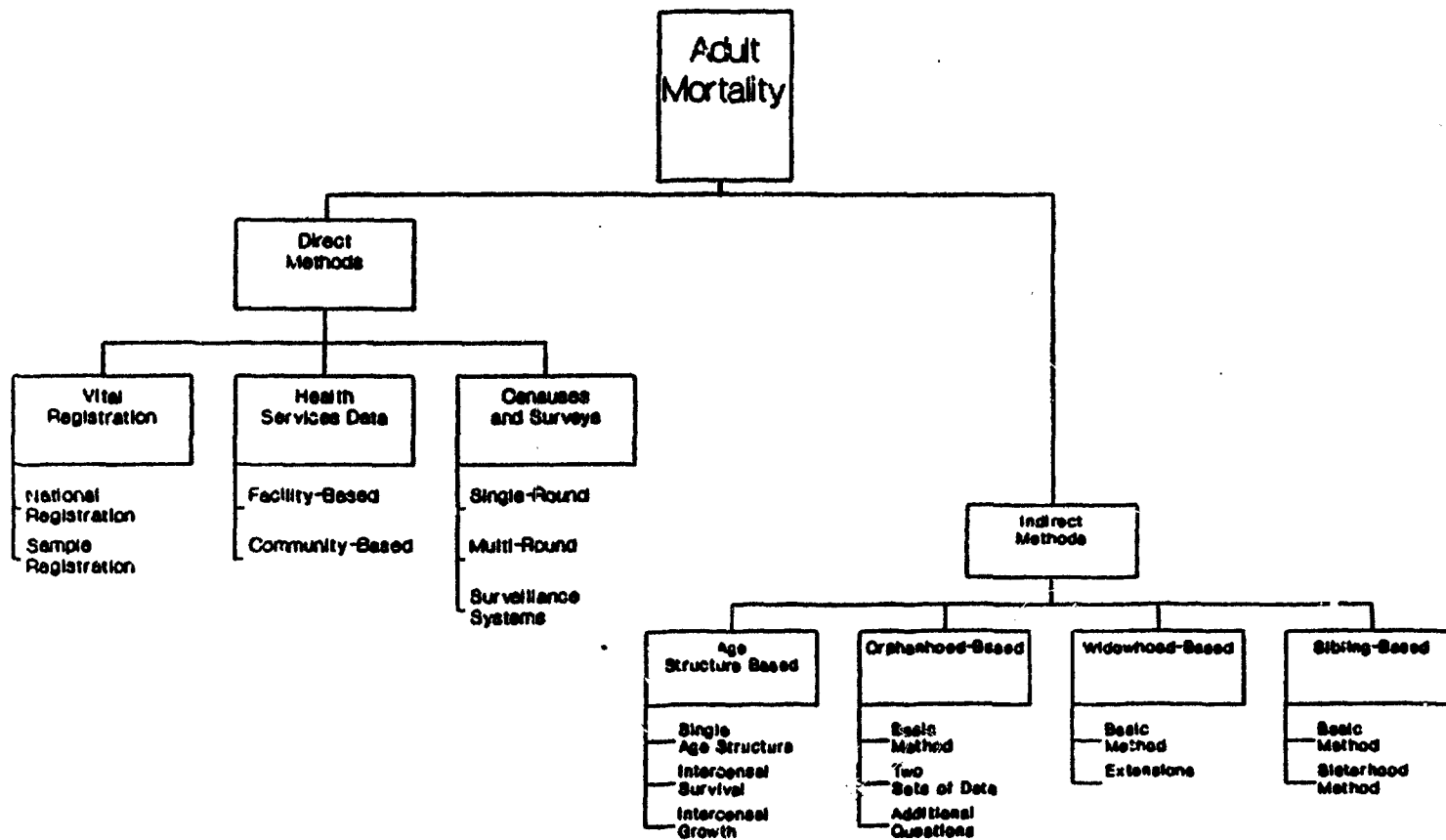


FIGURE 1

Classificatory schema for methods of measurement of adult mortality.

obviously by the development of the indirect methods that are discussed in a later section of the paper, it has had long-lasting administrative and financial effects.

The term 'direct' describes the unifying characteristic of this group of information sources, methods and measures, namely dead individuals. Levels, trends and differentials of mortality are derived directly from data on deaths rather than from data to which deaths can be related, as in the case of indirect estimation. In its simplest form, a direct measure is a count of deaths. Depending on the amount of additional information available related to these deaths, the measure may be expressed as a rate, ratio or proportion, and made specific by age, sex, cause, period, area, exposure to risk factors, and socio-economic characteristics. Such additional information tends to refer to the situation at the time of death, although earlier experience may be equally important; for example, former occupation, smoking history, number of sexual partners, or age at first birth. Direct measures can describe recent mortality levels: constraints on their timeliness arise largely from administrative and data processing delays.

The basic counts of deaths from which all direct measures are derived may be gathered more-or-less continuously, as in the case of vital registration or health service statistics, or periodically by including questions in a census or survey on deaths in the household during a recent fixed interval. Deaths may be identified by 'passively' relying on relatives notifying the authorities, or by 'actively' seeking events in the population. Additional information about the deceased may be supplied by the individuals themselves before their death, for example through a surveillance system, or afterwards by contact with their relatives. These features of the data vary according to the source of information and, in turn, influence the accuracy, degree of detail, availability and timeliness of the measures of adult mortality.

II. METHODS OF ANALYSIS AND MEASURES OBTAINED.

Methods for calculating direct measures of mortality are the subject of numerous basic demographic and epidemiological texts (eg. Shryock and Siegel, 1976; Alderson, 1976). The complexity of these methods varies largely according to whether 'observed' or 'adjusted' measures are calcu-

lated and to the procedure of relating death events to the population 'at risk'.

Typically, observed measures are simpler to calculate and interpret. The case-fatality ratio for a particular disease in a population of hospital inpatients, for example, can be computed directly as the number of deaths from the disease to the number of surviving cases. The analysis becomes more complex as the observed measures become more specific, such as age-, sex- and cause-specific death rates (WHO, 1977). One of the chief drawbacks of direct measures is that it is often necessary to use different sources of information for the numerator and denominator. For example, deaths may be obtained from the vital registration system while the population at risk may be derived from the decennial census. Besides the problem of incompatibilities between the different sources with regard to reference periods & definitions, variations in their accuracy and completeness, particularly in the numerator, can lead to biased measures.

There are a number of methods which may be used to assess the completeness of registered death information and thus to adjust the data so that it may be used. A distinction can be made between methods based on comparisons with data from independent sources, such as censuses or surveys, and analytic methods based on assumptions about population age distributions. The former methods are reviewed by Preston (1984) and are based on the Chandrasekaran-Deming correction which assesses completeness by matching deaths from two independent sources. The primary alternative sources to the registration system are, firstly, household surveys in which questions are asked about deaths in a comparable reference period and, secondly, active reporting of deaths by local informers. The major drawbacks to such assessment stem from lack of independence between the two sources, incompatibility in the area covered or reference period used, and the inherent difficulty of identifying true matches between deaths reported by the two sources (Marks *et al.*, 1974; Wells, 1974; Myers, 1976).

In recent years a range of analytic methods have been developed to assess the completeness of reporting of deaths and to adjust such data (eg. Brass, 1975; Preston *et al.*, 1980; UN, 1983). The basic idea underlying such methods is that everyone who reaches any given age must die at an older age. Therefore, on the basis of a number of simplifying assumptions, it is

possible to compare the age distribution of deaths with information on the age structure of the population and obtain measures of the completeness of death reporting. While such methods were conceived originally as a way of adjusting deficient registration data, they can also be applied to information on deaths in a fixed reference period collected in various forms of household survey.

The most basic assumption made by these analytic methods is that the level of under-reporting of deaths is invariant by age. It is generally agreed that this is unlikely to extend to child deaths and so the methods can only be applied to data on adult mortality. In order to estimate the number of deaths that should be reported above each age, both the growth balance method (Brass, 1975) and the Preston and Coale (1980) method assume that the population has a stable (ie. unchanging) age structure. The growth balance method compares deaths occurring above each age with the population of that age, while the Preston and Coale method uses detailed information on ages at death and a measure of the growth rate to assess the completeness of death reporting. The latter method is more vulnerable to exaggeration of ages at death than the growth balance method but is less sensitive to departures from stability caused by mortality decline. The assumption of constant under-reporting of deaths by age seems to hold widely and both procedures have the advantage that they indicate when the assumptions are invalid and their use inappropriate. Available evidence suggests that they give similar results with data of reasonable quality. However, both procedures are difficult to apply in populations that are heavily affected by migration or where the reporting of age is very poor. In particular, they can seldom be used to adjust data on sub-national populations.

Bennett and Horiuchi (1981) have suggested a procedure for assessing the completeness of data on recent deaths which does not assume stability and can be used when the age structure of the population is changing. To apply the method it is necessary to have information on the age distribution of the population from two separate enumerations so that the rate of growth of each age group can be calculated. These estimates are therefore vulnerable to changes in census coverage. Courbage and Fargues (1979) suggest a different way of avoiding the assumption of stability. Like the other analytic methods, their approach assumes that the under-reporting of deaths

is constant by age. It proceeds by comparing the degree to which the reported deaths are concentrated in old age with equivalent measures in model life tables. While the method is rather sensitive to age reporting errors, it only requires one enumeration. Its major advantage is that it can be applied to populations that are affected by migration, such as those of urban areas where death registration may be relatively complete.

The existence of these methods implies that even deficient registration data may be useful for the estimation of the level of mortality in adulthood in specific circumstances. However, they are unlikely to be usable in countries where only a minority of deaths are registered or registration coverage is very patchy. Moreover, they do not provide much help in attempts to analyze data on causes of death from deficient registration systems, as the probability of a death being registered is likely to vary according to cause of death.

Whether or not they are adjusted first to overcome incompleteness, direct measures are frequently expressed as hypothetical representations of the level of mortality for a given population group. One of the most well known methods for summarising and adjusting death statistics is the calculation of a life table, in which death rates are re-expressed as probabilities of dying (mortality rates) or surviving and as measures of life expectancy. Alternatively, the crude death rate for adults, conventionally defined as the population over age 15, may be standardized to allow for the age structure before comparisons are made with the rate from another population of adults.

In situations where the information on deaths cannot reliably be related to the true population at risk, as for example with hospital deaths, numerator analysis may be appropriate. Such analyses involve comparisons between sub-groups within the numerator. The calculation of proportionate mortality ratios is one such application, the comparison being between different causes of death, age groups or sexes. Clearly this method is highly sensitive to differentials in the accuracy and completeness of reporting between the comparison categories. A special variant of numerator analysis is based on case-control designs. Such studies would compare a group of deceased adults (cases) with an equivalent group of surviving individuals attending a health facility (controls). For example, maternal

deaths occurring in a hospital might be compared with women surviving deliveries to measure the risks associated with such factors as previous adverse pregnancy or obstetric outcome. Case-control methods are particularly useful for studying rare conditions and causes of death and may be conducted using hospital records or by tracing and questioning relatives of the cases and the controls (Schlesselman, 1982).

III. SOURCES OF DIRECT MEASURES.

A. Vital Registration.

1. National Registration.

a) Basis and rationale. 'The most important source of information about mortality levels, trends and differentials has been historically and remains currently the continuous recording of deaths and their characteristics by civil registration' (UN, 1984). This view is, however, increasingly being challenged in developing countries. Very different issues are raised by registration systems that are used solely for administrative and legal purposes compared with those that are used for the planning, management and evaluation of health and development programmes. Traditionally, official mortality statistics were produced as a by-product of civil registration laws requiring death records to be filed as a means of ensuring appropriate disposal of bodies (Moriyama, 1984). Many developing countries acquired similar laws during the colonial period. This may have seemed both reasonable and necessary for rapidly growing urban populations but the relevance and practicality of enforcing these laws in rural areas remain important and controversial issues. The inadequacies of vital registration systems and the limited prospects for their improvement have featured as regular topics of discussion and resource investment among national and international statistical agencies since the early 1960s.

The legal status of death registration renders it compulsory, ensures the enforcement of registration fees and penalties for late reporting and identifies the person responsible and place of registration. In most developing countries, a passive system of death reporting operates whereby a relative of the deceased acts as a notifier and supplies the legally required information to a registrar (UN, 1984). The latter usually has an office located centrally within the administrative district. Thus time and funds

have to be expended by relatives to report a death. Incentives for notification can be provided by the need for a burial certificate from the registrar, particularly in urban areas, or because legal evidence of death is needed to settle life insurance and inheritance claims. Where informants do not need a death certificate for such reasons, notification is, not surprisingly, often incomplete. Active systems of registration have sometimes been introduced in such circumstances, whereby local informers assume legal responsibility for reporting vital events within a specified population. For example, village headmen or local school teachers may be appointed registrars in rural areas and required to actively seek the necessary information to register a death. This system has been introduced in a number of African countries (Hill and Graham, 1988).

The information obtained at registration may be divided into that concerning the individual and that concerning the event. The former information generally includes age, sex, marital status, occupation, place of residence, and nationality; in certain cases, additional data may be collected on fertility (eg. number of children ever born), and cultural factors (eg. religion, education). In the case of the death event, information is usually collected on the time, date and place of death (eg. at home or in hospital) and on the cause of death. An important distinction needs to be made between medically certified and uncertified data on causes of death. The former type of data may detail the mode of death (eg. toxic shock), its direct cause (eg. sepsis) and underlying cause (eg. induced abortion), contributory causes (eg. anaemia), and non-contributory causes (eg. chronic rheumatoid arthritis) (WHO, 1977). In most developing countries only a small and highly selective fraction of deaths are medically certified and uncertified causes are more common. The latter may be attributed by the reporting relative or assigned by the registrar based on symptoms reported by the relative. In these circumstances, the proportion of deaths grouped under 'Unknown' is usually substantial, reducing the value of any form of numerator analysis.

b) Experience and assessment. Evaluations of the vital registration system have been carried out in virtually all developing countries, largely under the auspices of UNFPA and often with technical support from the International Institute for Vital Registration and Statistics. There are

also a large number of general reviews of the value of official death statistics in the study of mortality (Linder, 1981; NAS, 1981). It is useful to consider the findings of such assessments under two major headings: completeness of registration and the accuracy of the reported information.

The registration of deaths in developing countries often falls far short of the 60 per cent completeness generally regarded as the lowest limit of coverage for the data to be usable (Preston, 1984). Registration completeness varies considerably within and between countries, depending, for example, on the cause of death and the age and socio-economic status of the deceased. Generally speaking, coverage is highest in Latin American countries and lowest in Africa. It is higher in urban than in rural areas, higher for locally common (eg. tuberculosis) or sudden (eg. violence, accidents) causes of death, higher for adults than children, and higher for richer socio-economic groups than the poor.

There are two major groups of reasons for incomplete registration of deaths: the first concerns the reporting of deaths and the second the processing of the information. Typically, both factors operate in developing countries, though their relative importance varies. Thus, for example, in many Latin American countries a high proportion of deaths are reported to the authorities but administrative constraints delay official registration and compilation of statistics (Gonzales Diaz 1988). In many African countries, this problem is less serious simply because a smaller proportion of deaths are reported in the first place. At a national scale, coverage may be incomplete because vital registration is totally lacking in parts of the country and/or because there is serious under-reporting within the areas covered (Shryock and Siegel, 1976). Deaths may be unreported owing to the lack of incentives for doing so, to lack of knowledge of the legal requirement to register deaths, to feelings of culpability, for example, in cases where professional assistance was not sought, to the costs involved in registration, to the absence of any close relatives, or to the sensitivity of the event, as is often found with child deaths.

The value of vital registration for studying adult mortality depends on the accuracy as well as the completeness of the reported information. Important dimensions of accuracy, besides the common problem of age mis-reporting, are the place, time and cause of death. Failure to allocate

deaths to the place of usual residence of the deceased can lead to a significant 'occurrence' bias towards urban areas or the higher levels of fixed health facilities. Similarly, failure to reassign deaths from their date of registration to their date of occurrence can lead to biases in the apparent death rates for particular periods, which may be exaggerated by a consequent mismatch with the denominator information used to calculate rates. Finally, a major limitation of vital registration data arises from imprecision in reported causes of death. Such misclassification biases affect registered deaths in both developed and developing countries. For example, it is estimated that almost a third of maternal deaths in the United States and England and Wales are incorrectly attributed to other causes (Cates et al., 1982). In developing countries, errors arise from the high proportion of deaths which are not medically certified and assigned to the wrong cause or to the 'unknown' category. For instance, in Wurie's (1979) study of adult deaths (15-44) in Greater Freetown, Sierra Leone, 33 per cent of deaths fell into the unspecified category.

2. Sample Registration.

a) Basis and rationale. The limited prospects for establishing reliable and complete national registration systems in most developing countries in the foreseeable future have prompted a search for alternative and interim sources of mortality data. One of these alternatives is sample registration. As the name suggests, this involves the reporting of deaths in a sample of areas which can then be related to a larger population. Concentrating registration in selected areas may achieve a higher level of quality and completeness than dispersing resources across a national registration system. In addition, a sample of appropriate design and size is adequate to meet most of the statistical objectives of collecting mortality data (UN, 1984).

A variety of types of sample registration systems can be identified. Some systems are scaled-down versions of a national system, gathering the same range of information in a passive manner by relying on relatives to notify an appointed registrar of a death. However, since financial and personnel resources are concentrated in selected areas, more active reporting systems are common. In such systems locally-based informers are responsible for

seeking out deaths among the population. The most famous and longest-running sample registration system is found in India. Launched in the early 1960s, this system covers a nationally representative sample of the population using what is known as a 'dual record system'. Continuous reporting of deaths by a local enumerator is complemented by an independent household survey carried out every six months. Deaths from these two sources are then matched and inconsistencies checked in the field (Padmanabha, 1984).

b) Experience and assessment. While sample registration appears to offer the possibility of overcoming some of the major disadvantages of national systems, its value is not widely appreciated. A major operational problem with sample registration systems is that rather few events will occur in registration areas of a size that a registrar can know well enough to find out about all deaths (Brass, 1971). Thus, justifying sufficient remuneration to maintain the motivation of registrars is difficult. A baseline census of the population in the sample area may provide a denominator for the calculation of rates, but, in the absence of constant updating which allows for migration as well as births and deaths, this comparative advantage is soon lost. Dual record systems such as the Indian Sample Registration Scheme do appear to be successful at reducing the omission of deaths. Unfortunately they are very expensive. Maintaining the independence of the two systems in the field is difficult and the matching of events at the analysis stage is a formidable task. Finally, while registering deaths in a sample rather than national population is operationally simpler, there are still considerable costs involved in sustaining the accuracy and completeness of the information.

B. Health Service Statistics.

1. Facility-based Statistics.

a) Basis and rationale. Information gathered at fixed health facilities has two main uses: individual patient management and health services management. In the case of deaths, the data are clearly only relevant to the latter purpose. Death returns by fixed health facilities have thus come to be regarded as indicators of poor performance, both in developed (Cochrane et al., 1978; Kind, 1988) and developing countries (Hansluwka, 1985; WHO, 1981). In certain circumstances this role adversely affects the reliability,

timeliness and completeness of the information. Such factors also vary greatly between the tiers of the health service. In most developing countries, a distinct hierarchy of services exists, usually ranging from specialist referral hospitals through district hospitals to local clinics. All of these, except possibly the latter, have in-patient facilities. Deaths reported through these services tend to be events occurring at the facility; individuals brought to the facilities after they have died may or may not be included. If death reporting is also carried out through primary health care workers within the community, this can lead to either omission or double-counting of events.

Although the health services represent a source of continuously-collected information, serious problems with the aggregation and forwarding of returns to a central authority and failure to allocate responsibility for publishing statistics, frequently represent major constraints on the value and utility of information from this source (Hill and Graham, 1988). These difficulties often arise from lack of commitment or of time to record data on the part of health personnel. This, in turn, is often linked to the absence of feedback from further-up the reporting hierarchy. Problems may also be caused by the administrative separation of responsibility for collection and processing the data between, respectively, the Ministry of Health and the authority for statistical services. Moreover, deaths at non-governmental fixed health facilities may not be captured through the official reporting network.

The details on deaths which are collected at fixed health facilities and are available in aggregated or disaggregated form, vary enormously. Their scope depends on such factors as the type of facility, cause of death, type of admission (eg. emergency), and presence of relatives. Sometimes only the number of deaths by sex are compiled. Although it is generally believed that the most reliable information about causes of death is derived from the health services, the accuracy of such data varies considerably between facilities. Thus, for example, the cause of a maternal death is more likely to be reported as a 'ruptured uterus' at facilities with emergency obstetric facilities, whereas at lower level facilities it may be reported as 'obstructed labour'. While allowing for the range of circumstances found in developing countries, concerted efforts to standardize the procedures for attribution and classification of direct and underlying causes have long

been made by WHO. This rarely seems to be given an equivalent priority by Ministries of Health.

b) Experience and assessment. The routine reporting of deaths through health facilities is the major source of mortality data in the more developed countries, where differential accessibility and utilization are not key issues and where most deaths occur in or are brought to these facilities. Clearly, however, this is only true of a small, but unknown, fraction of deaths in developing countries. The problem of selectivity has been widely discussed but rarely quantified. Potential selection biases in the deaths reported by health services can be due to factors associated with the individual (eg. socio-economic status, education), the cause of death (eg. acute versus chronic conditions), the level of service and thus catchment population (eg. national referral centre versus local clinic), and the area (eg. urban versus rural). Interpretation is further complicated by interactions between such selection factors. Thus a major drawback to analyses of data compiled from health facilities is the difficulty of applying the findings to the general population or indeed identifying the population to which they have some relevance.

One of the consequences of the difficulties involved in identifying the population at risk of dying in hospitals and clinics is that true rates of adult mortality can rarely be calculated using data from fixed health facilities. Numerator analysis may be used to look at, for instance, case fatality ratios among patients presenting with particular diseases. A good illustration of the use of health services data in combination with mortality data from the decennial census, is provided by the Ghana Health Impact Assessment Project (1981). This yielded a measure of 'healthy days of life lost' owing to mortality or morbidity from different illnesses, as a means of determining priorities for resource allocation. Two further methods of analysis commonly applied to health services data are record reviews and case-control studies.

In recent years increasing emphasis has been placed by governments and international donor agencies on integrated health information systems, bringing together data from different sources (WHO, 1988; Nabarro and Graham-Jones, 1987). Comparatively little attention has been paid, however, to identifying and assessing the consequences of selectivity in fixed health

facility data; a problem which will remain even if the goal of universally-available health care is attained. The development of community-based reporting networks based on primary health care workers represents a potential answer.

2. Community-based Reporting.

a) Basis and rationale. This source of information on mortality has many similarities to sample registration based on local informers which we describe earlier in the paper. The principal differences lie in the personnel involved and the authorities responsible. Community-based reporting under the auspices of the Ministry of Health is undertaken as one of the responsibilities of health workers who would normally reside with the population for whom they provide primary health care. The level of training and range of activities of these workers varies enormously between developing countries, as does the range of information that they collect. For example, in many African countries, the trained traditional birth attendant (TBA) is responsible for recording births, stillbirths, early infant deaths and maternal deaths, while deaths among the rest of the population are reported by the local primary health worker (Graham, 1986).

At their most basic, health service community-based reporting systems may simply involve counts of deaths, especially in situations with low literacy skills among the health workers. Additional information may, however, be available if records are kept by these workers on each of the families under their responsibility or if a baseline household survey was conducted prior to the introduction of primary health care (Kaseje, 1988). Information on deaths in the community is, however, rarely used locally but often passed-up the health services reporting hierarchy to a central authority, usually at a district or regional level, or to the fixed health facility from which the community health worker is supervised (Hill and Graham, 1988).

The coverage and quality of community-based reporting often varies considerably within a developing country, largely reflecting differentials in the availability of health care. In some countries, a form of sentinel site reporting has evolved whereby the information-gathering responsibilities of primary health workers are confined to a small number of communities selected to be representative of the population of the district (WHO, 1981).

In the remaining communities only basic data needed for local-level management are gathered.

A further variant of community-based reporting linked to the health services is epidemiological surveillance. Except in the case of fatal epidemics, such as measles or cholera, this surveillance often only gathers information on disease cases rather than deaths. It is rarely possible to relate these numbers to the population at risk.

b) Experience and assessment. There are a few examples of health service community-based reporting systems which have been operating for over a decade but the majority have emerged since the Alma Ata Declaration on primary health care in 1978. There have been comparatively few systematic evaluations of these more recent systems, although information-gathering is usually one of the subjects considered during progress reviews of primary health care in developing countries (WHO, 1984).

The full potential of such systems as sources of data on adult mortality has yet to be explored. However, certain factors currently restrict their utility. Firstly, since the health worker supplying the information may feel in some way culpable, a natural tendency exists for under-reporting. Thus, for example, TBAs have been noted to underreport maternal deaths in their community (Graham and Airey, 1987). Secondly, deaths may be omitted, or possibly counted twice, when an individual is referred by the health worker to a fixed health facility prior to death. Thirdly, given the comparatively low level of training received by local health workers, they are unlikely to be a reliable source of cause-specific information on mortality. Finally, one of the major constraints on the quality of data is the extra burden that information-gathering imposes on community health workers and the limited value they may attach to this activity, particularly when there is little feedback from higher levels of the reporting network.

C. Censuses and Surveys.

1. Single-Round Surveys and Censuses.

a) Basis and rationale. An obvious and simple way of trying to measure mortality levels directly in a census or household survey is to include questions about deaths that have occurred in the household during a fixed period before the enumeration. Most enquiries ask about deaths in the

preceding year; the WFS, however, experimented with a two year reference period and asked about the exact date when each death occurred. Information is usually collected on ages at death, the sex of the deceased and sometimes their relation to the household head. After making minor adjustments for population growth, the enumeration of the living population in the same enquiry provides appropriate denominators for the calculation of mortality rates. Methods for evaluating and adjusting data on deaths by age which were discussed earlier, with reference mainly to registration data, are equally applicable to the results of single-round surveys.

Questions on recent deaths can only yield usable estimates of mortality in fairly large-scale surveys or censuses. Even in high mortality countries, death is a relatively rare event and the sampling errors of mortality rates are relatively large compared with their absolute size. Blacker and Scott (1974) suggest that a survey of about 20,000 households is about the minimum size that might yield reasonably precise estimates. Often even larger enquiries would be required.

b) Experience and assessment. There is considerable experience of this approach to measuring adult mortality. Questions about recent deaths have been asked in a large number of surveys conducted on far too small a scale to yield useful results. Even in larger enquiries, the results have often not been processed, either because only a handful of deaths were reported or because the data processing system was designed to handle a record for each individual and could not cope with household-level data.

The results suggest that it is common for a substantial proportion of recent deaths to be omitted. Often only about a third to one half of the expected number of adult deaths are reported and sometimes far fewer. There seem to be several reasons for this. One major problem is that deaths only occur in a small minority of households and interviewers simply give up asking the question and leave that section of the schedule blank. In addition, reference-period errors may be important and also omissions, perhaps because of an unwillingness on the part of respondents to talk about the dead. In several WFS surveys the number of deaths reported each month declined rapidly as the interval between their occurrence and the survey increased (Timæus, 1987). Coverage errors are also a problem. Not everyone is clearly attached to a single household and some people live alone. Such

individuals may be among those most likely to die but are unlikely to have their deaths reported. Moreover, the death of an adult can often precipitate household fission so that the households in which deaths occur may disintegrate before the survey is conducted.

If only a proportion of adult deaths are reported it may still be possible to adjust them using the growth balance method and related techniques. Unfortunately the combined effects of migration, age misreporting and sampling errors often mean that few firm conclusions can be drawn from such analyses. Typically one can only conclude either that the data may be complete, though not whether they are, or that the data are definitely incomplete, though not how incomplete (eg. Timæus, 1987). In some countries, concentrating on the data for women, who may be less likely to migrate, or re-tabulating the data using unconventional age groups, to alleviate the problem of heaping of reported ages on those ending in the digits 0 and 5, may facilitate assessment of the completeness of reporting.

It is important to add, however, that sometimes questions about recent deaths in single-round surveys work well. In nearly half the WFS surveys considered by Timæus (1987) such questions yielded estimates of adult mortality that were comparable with those from other sources. Thus the approach is unreliable, rather than useless. Unfortunately its performance can seldom be assessed on the basis of internal evidence. In addition, sampling errors and errors in the reporting of ages at death mean that it is seldom possible to accept the age-specific mortality rates as they stand. Usually the data have to be smoothed by fitting a model life table. Thus they are of little use for studying age patterns of mortality in detail. Finally, information on recent deaths are of limited use for the study of mortality differentials. Even if sample size constraints do not prohibit disaggregation, it is difficult to collect information retrospectively on the characteristics of the deceased. In addition, techniques for assessing and adjusting data on recent deaths cannot be applied to sub-populations that are affected by migration. Even when these methods work well at a national scale, it is unreasonable to suppose that the level of reporting is invariant across regions or social groups.

2. Multi-Round Surveys.

a) Basis and rationale. Multi-round surveys attempt to circumvent the problems experienced when asking about deaths in the household in a single-round survey by enumerating and then re-enumerating the same population and enquiring about deaths in the intervening period. Since enquiries can be made about each individual present in the first enumeration but not the second, multi-round surveys eliminate most of the omissions and reference-period errors that vitiate the single-round approach. In addition, as age and other personal characteristics can be collected from individuals themselves in the first round, multi-round surveys investigating household change yield much more reliable data than single-round surveys for the study of age-patterns of mortality and mortality differentials.

In contrast to sample registration systems, multi-round surveys are based on an enumeration of the study population. As well as assisting in the detection of events, this means that they provide their own denominators for the calculation of rates. The distinction between multi-round surveys and surveillance systems, however, is to some extent an arbitrary one. Typically, multi-round surveys are focused on demographic estimation, aiming to measure fertility and migration as well as mortality. Such surveys are usually conducted over a fixed period, most often one year but sometimes longer, and make no attempt to remain in contact with the population in between rounds of the survey. The frequency of visits affects the level of omissions of events and rounds of the survey may be conducted at yearly intervals, 6 monthly intervals or, ideally, every 3 months. One exception to this pattern is the Population Growth Estimation (PGE) surveys conducted around 1970. These combined continuous recording of vital events with a separate multi-round survey of the same population. These surveys were thus a form of dual-record enquiry with a similar design to that implemented on an on-going basis in the Sample Registration System of India.

As with the single-round approach to measuring adult mortality that we discuss in the previous section, multi-round surveys need to cover some 100,000 person years of exposure to yield sufficiently precise data for the study of mortality levels. To take advantage of the potential that multi-round surveys offer for the study of differentials in adult mortality, the samples would need to be considerably larger. This sample needs to be

interviewed at least twice and the cost of each round often approaches that of a single-round survey.

b) Experience and assessment. Multi-round surveys have been conducted in most regions of the world and a great deal of attention has been devoted to their assessment (eg. Adlakha and Nizamuddin, 1984; Scott, 1973; Tabutin, 1984). The UN Latin American Demographic Centre (CELADE) devoted considerable resources to studies of this sort during the 1960s and 1970s and there is a strong tradition of such surveys in francophone Africa.

There is little dispute that, if well conducted, such surveys are one of the more reliable ways of measuring mortality in countries that lack effective routine sources of data (eg. Seltzer, 1969). However, they reduce rather than eliminate problems, such as age misreporting, and suffer from distinctive technical problems. The field operations are inherently complicated, they require meticulous record keeping and supervision and loss to follow up is almost always a problem, especially in highly mobile groups such as the populations of many urban areas. Events only occur in a small minority of households between any two rounds of the enquiry and maintaining the motivation of interviewers is very difficult. At their worst, multi-round surveys combine the operational problems of both single-round and continuous data collection systems. Moreover, they are expensive and highly demanding of technical and managerial expertise. Finally, as multi-round surveys involve a protracted period of fieldwork, they inevitably suffer longer delays in the production of results than single-round surveys.

3. Population Surveillance Systems.

a) Basis and rationale. Population surveillance systems are hybrids of the various sources of direct measures of mortality described above, including vital registration, censuses and surveys and health service statistics. Characteristically, these systems are set-up with specific research-oriented objectives often in the field of public health, and cover relatively small, clearly-defined populations using intensive and frequently costly methods of data collection. Such systems are often established for fixed periods. However, the huge investment of time and financial resources involved sometimes ensures that they are maintained after the original

objectives have been met and they thus become long-term, continuous sources of mortality and morbidity information.

As so-called 'population laboratories', these systems are often the site of experimental studies of specific health interventions, such as vaccine trials; of particular measurement techniques, such as digital weighing scales; or of operational or management structures, such as decentralised provision of health care. Thus the range of information gathered by these systems is enormous. Typically, a baseline population census forms the starting point. Subsequently, information on vital events may be collected more-or-less continuously using village-based informers (who may also provide some health services). Periodic household surveys, on a complete or sample basis, are usually conducted to elicit more detailed information, often on morbidity. Surveys may occur at such frequent intervals that they yield effectively continuous data. The analysis, interpretation and utilization of these data are usually carried out within the system by specialised personnel, rather than being forwarded to a central statistical authority and thus integrated with a wider information network.

b) Experience and assessment. In recent years, population surveillance has received considerable attention within the overall efforts to improve the information systems of developing countries. There are many of these 'laboratories' now in operation. Comparatively few are the direct responsibility of the national government, and the role of international, bilateral and non-governmental agencies in establishing and maintaining these surveillance areas remains critical. Given this situation, it is extremely difficult to identify, let alone describe and assess the activities of all the systems currently in place. There have been reviews of the more famous and long-running population surveillance areas (D'Souza, 1984; Faruquee, 1982). These include systems in Bangladesh (Matlab and Companiganj), Ghana (Danfa), the member countries of INCAP (Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama), Kenya (Machakos), The Gambia (Farafenni), Senegal (Ngayorkheme), Thailand (Lampang) and India (Narangwal). The 'laboratories' operating in sub-Saharan Africa have recently been evaluated with regard to the study of disease and mortality (Feachem, in press). However, the lack of a up-to-date and comprehensive review of population surveillance systems in other parts of the world is a serious constraint to

the full assessment of the potential of this source for studying adult mortality.

There are some obvious comparative advantages to information systems over the alternatives. The intensity of observations within population surveillance areas, together with the use of well-trained reporters, result in good quality data with high levels of completeness. Collection of accurate cause-specific mortality information, however, has not generally been attainable. The clear identification of the population at risk enables true rates to be calculated for specific sub-groups, areas and time-periods. Given the longitudinal nature of these systems, mortality trends may be assessed and related to specific health interventions whilst controlling for extraneous factors. The information available on deceased individuals, through earlier prospective data collection or from subsequent interviews with relatives, is often detailed and reasonably reliable and may provide invaluable insights of the processes and risk factors associated with premature adult deaths.

The advantages of population surveillance systems are counter-balanced by a number of limitations and disadvantages. The most frequently cited of these is their cost (D'Souza, 1984). The high expense seems to stem not so much from the size of the population under surveillance as from the considerable costs of well-trained and supervised personnel and of transportation for these staff. The financial and labour resources needed to sustain the high quality of the information, preclude their expansion to larger populations. Many surveillance systems cover too small a population for it to be possible to study adult mortality in depth and some have simply not collected data on adult deaths. The intensity of observations, the infrastructural support and the interventions carried out clearly create an artificial situation with inevitable effects on the surveillance population. Questions therefore arise concerning the wider relevance of the findings. Finally, the sheer volume of information gathered by population surveillance systems has hampered the prompt availability of results and often delayed the production of regular reports. However, the wider use of micro-computers during data collection and analysis will undoubtedly ease these problems in the future (Snow and Brass, 1988.)

IV. POSSIBLE DEVELOPMENTS IN DIRECT MEASUREMENT

The direct means of measuring adult mortality together represent an impressive armoury of methods in the context of the information-oriented cultures of developed countries. Yet one of the most valuable potential applications of these methods has still to be fully explored, namely the powerful data base which could be created by the integration of materials from the various sources. Undoubtedly, more can be gained by linking information together, at both the individual and aggregate levels, rather than using it independently (Baldwin *et al.*, 1988). However, there are still remarkably few examples of such linked information systems, although the principle is well-supported (WHO, 1988). In the case of developing countries, the benefits of integration could be even greater since none of the sources of mortality data are adequate, by themselves, for the needs and demands of health planning, management and evaluation (Hill and Graham, 1988). The major constraint on the development of integrated information systems is not, however, peculiar to the developing countries but arises from the nature of the sources of direct data on mortality. The administrative and clerical effort involved in the collection of information on recent deaths is considerable and can be related largely to the size of the operations (whether vital registration, surveys or health service statistics) required to gather sufficient numbers of deaths to calculate usable measures. Fortunately, the current priority being given in many developing countries to rationalizing the direct sources and the greater use of microcomputer technology in data collection and analysis hold out some hope for the future.

There are four possible areas for further development of the direct approach to the measurement of adult mortality which may be suggested here. Firstly, the health services represent a key source of both morbidity and mortality information. With the emergence of community-based reporting the value of the data is increasing. Greater attention needs to be paid both to the gaps and the overlaps in information from this source and to the issue of selectivity. The introduction of a few simple questions to health service records, such as village of residence, could help to identify the catchment area of various facilities. Secondly, while the expensive population surveillance systems currently in operation have limited wider appeal, a comprehensive review is needed of the major lessons learnt from them and the

potential for development of scaled-down and lower cost systems. Thirdly, improvements in cause of death ascertainment are essential to the understanding and ultimately the reduction of the level of adult mortality. While validation of diagnoses has long been a subject of great debate in the medical profession, progress in the context of developing countries seems more likely to emerge from fresh initiatives. These might, for example, be based on the WHO-sponsored classification of lay reporting of cause of death used in conjunction with both health service community-based reporting and continuous surveys programmes, such as the UN Household Survey Capability Programme. Finally, while age misreporting has been recognized as a major problem in mortality estimation for many years, most research on methods for obtaining better age estimates have occurred in the context of survey research. New initiatives to improve the age data collected by routine reporting systems would benefit both the direct and indirect measurement of adult mortality.

INDIRECT MEASURES OF ADULT MORTALITY.

I. NATURE OF THE INFORMATION.

Indirect methods represent an attempt to overcome the difficulties that arise in the collection of information about dead individuals and especially about individuals who died a considerable time ago. These methods are based on data that can be collected in single-round surveys or censuses about the current characteristics of respondents and, in particular, their age. Thus the defining characteristic of the methods considered in this section of the paper is either that they use aggregate data on the age distribution or that the unit of analysis is a relative of the deceased and not the person who has died. In the latter case, it is the details of the informant that are used in the analysis rather than those of the dead individual. Analytical sophistication, involving models of known demographic relationships, is substituted for sophisticated (and therefore more expensive) methods of collecting data.

The data used to estimate mortality indirectly, on the basis of special questions put to respondents, are the proportions surviving of some clearly

defined category of relatives of the respondent. These proportions are analyzed according to the respondent's age. For example, respondents may be asked 'Is your mother alive?' and a tabulation produced of the proportion of respondents with mothers in each five-year age group. On the basis of this information and supplementary data, it is possible to work back to measures of the level of adult mortality that produced the proportions surviving observed among the respondent's relatives.

II. METHODS OF ANALYSIS AND MEASURES OBTAINED.

The development of indirect methods for estimating mortality and, in particular, adult mortality is originally associated with W. Brass and his collaborators, though many other individuals have since made important contributions to the field. In essence, the proportion of relatives that remain alive at the time of data collection depends largely on the level of mortality, the average age of the relatives and the time over which the relatives were exposed to the risk of death. The average length of exposure can be calculated from information about the respondents. For example, a respondent's mother must have been alive when the respondent was born, and similarly, both spouses were alive at the time their marriage occurred. The relationship between the ages of the respondents and those of any category of their relatives can be expressed mathematically and depends on demographic processes which can be adequately represented by simple models. Thus adjustment procedures can be derived whereby information on the survival of relatives can be translated into conventional life table measures on the basis of a simple index of the average difference between the ages of the respondents and their relatives.

Although the rationale of the indirect methods of measuring adult mortality is a little difficult to understand, the basic limitations of the approach arise not from the approximations that are involved in the process of estimation but from the basic nature of the data analyzed. The proportion of mothers, or any other category of relatives, that remain alive depends on the level of mortality over a range of ages and a number of years. There is no way in which the relative levels of mortality at older and younger ages and in the recent past and longer ago can be determined without making further assumptions. In practice what is done is to assume that the age

pattern of mortality can be adequately represented by some model pattern. If it is further assumed that the level of mortality has declined linearly in terms of that model, it becomes possible to estimate the date at which the mortality of the cohort of relatives reported on by each age group of respondents equals the period measure of mortality prevailing in the population (Brass 1985; Brass and Bangboye, 1981). As these dates are nearer to the present for younger respondents than for older ones, these 'time location' methods make it possible to measure the general trend in mortality. Indirect methods generally yield only broad measures of the overall level and trend in adult mortality and not detailed schedules of age-specific mortality rates for particular years. More detailed information can be derived from the average patterns encapsulated in systems of model life tables but the methods are inherently unable to detect abnormal age patterns of mortality within adulthood or short-term fluctuations in mortality.

While the fact that information on the survival of relatives refers to the experience of cohorts rather than deaths in a single year is a disadvantage for the study of mortality trends, it is an asset for examination of mortality differentials as many pertinent characteristics for the study of mortality remain fixed during adult life (Brass, 1980). On the other hand, the only data usually available on socio-economic characteristics concern the respondent at the time of the enquiry rather than their relatives. Insofar as these characteristics differ from those of deceased individuals at the time of death, any effects on mortality will be masked by misclassification biases. Despite this problem, some studies of this sort have documented large differentials in adult mortality and more consideration needs to be given to the analysis and interpretation of such data.

III. SOURCES OF INDIRECT MEASURES.

A. Census Age and Sex Distributions.

1. Single Age Distributions.

a) Basis and rationale. An age distribution is the outcome of the history of births, deaths and migration experienced by a population over the preceding century. Unfortunately fertility and, in many countries, migration have a greater impact on age structure than mortality. Thus, in general, it is difficult to derive mortality estimates from single age distributions. In

populations that have experienced little net migration, however, it is possible to attempt to estimate adult mortality so long as some independent information is available that can be used to control for the effects of fertility on age structure.

One approach to estimation, that requires minimal data, assumes that the population is approximately stable (ie. has an unchanging age distribution that results from constant fertility and mortality over a prolonged period). It proceeds by matching the proportion of the enumerated population aged under 15 with the equivalent proportion in a stable population model with the same rate of growth (UN, 1983). If the population's rate of growth and the proportion under 15 have been measured accurately, life expectancy at age five in the enumerated population will be approximately equal to the same measure in the stable population even if the age pattern of mortality used to generate the model is rather different to that in the enumerated population.

b) Experience and assessment. Most attempts to estimate mortality from single age distributions date back to a time when little other information was available. Methods based on stable population models can only be applied in countries that have experienced near constant fertility for a long period. While it is possible to try and adjust for the impact of migration or a history of mortality decline on age structure, such attempts are seldom very satisfactory. Moreover, errors in the estimation of the growth rate and proportion under 15 can seriously bias the adult mortality estimates obtained. Usually if data were available to estimate the growth rate (eg. from a second enumeration), one would be able to estimate mortality from intercensal survival or growth. This is very much a method of last resort.

2. Intercensal Survival.

a) Basis and rationale. Methods based on the change in the size of a population between two censuses are among the oldest ways of attempting to measure levels of mortality in the absence of registration data. As children enumerated in the second census and aged less than the intercensal interval will have been born after the first census, the approach can only be used to measure adult mortality. If international migration has a substantial impact on the population, estimating adult mortality in this way is usually

impossible but, if the level of migration is insignificant, mortality should be the sole factor leading to changes in the size of the adult population by age. Traditional procedures for estimating mortality using information from two censuses are based on cohort survival. In other words, the attrition of cohorts is examined by comparing the size of the population in each age group at the first census with the equivalent older age groups at the second enumeration. In practice, age reporting errors almost always raise major problems and a variety of methods have been proposed to adjust for and smooth out their impact (eg. Brass, 1975; UN, 1967, 1983).

Brass (1979) and Preston and Hill (1980) have proposed methods that combine information on intercensal survival with data on registered deaths by age in order to estimate both the completeness of the registration system and changes in census coverage. Despite the attractiveness of this idea, the methods appear very vulnerable to age exaggeration and are of more use as a means of estimating census coverage than mortality. If both registration and census information are available, the best way of analyzing the data is probably to apply the technique proposed by Bennett and Horiuchi (1981) and discussed earlier in the paper.

b) Experience and assessment. The information required to estimate mortality from intercensal survival is available in most developing countries and, in straightforward applications, the method does not involve the use of demographic models. Intercensal survival was in use before the indirect methods based on special questions were developed and continues to be of importance for the estimation of mortality in large countries such as India, where migration has a limited impact on population trends. The resulting estimates are often too erratic to yield evidence on the pattern of mortality by age. A more fundamental drawback, however, is that the results are very sensitive to changes in enumeration completeness over time. These frequently introduce large errors. Rather than treating data on intercensal survival as an independent source of data on mortality, it is probably more realistic to use an intercensal population projection as a means of assessing the possible errors in mortality estimates derived from other sources.

A further limitation of methods of mortality estimation based on intercensal survival is that they can seldom be used to produce sub-national

mortality estimates. Most socio-economic characteristics of individuals can change over time. Moreover, even if international migration is negligible, migratory movements within countries are almost always sufficiently large to preclude trying to estimate regional differentials in mortality in this way. Finally, it should be noted that, because it is only possible to measure mortality on the basis of intercensal survival once the second census has been processed, it will seldom be able to provide up-to-date estimates.

3. Intercensal Growth.

a) Basis and rationale. Preston and Bennett (1983) have proposed an alternative way of estimating mortality from two census age distributions that uses information on the growth in the size of the same age groups between two censuses to calculate a stationary life table age distribution from those reported in the censuses. All other life table measures of mortality can be derived from this distribution, though omissions and age reporting errors for young children mean that only those for adult mortality are likely to be reliable. A further development of the approach, which requires an independent index of the level of mortality in childhood, incorporates a procedure for smoothing the estimates by fitting a relational model life table (Preston, 1983).

b) Experience and assessment. This is a new way of estimating adult mortality and not much experience has been gained in its application. The method is as easy to apply if the censuses are not separated by exactly five or ten years as when they are. The method also reduces the impact of equivalent, though not changing, age reporting errors on the mortality estimates. Like intercensal survival methods, Preston's procedures are subject to biases arising from migration and changes in enumeration completeness. They are more flexible, however, and somewhat more reliable than those based on cohort survival and are, in general, preferable.

B. Questions about Orphanhood.

1. The Basic Orphanhood Method.

a) Basis and rationale. Information on orphanhood can be collected using two simple questions that can be included on the interview schedules used in censuses and household surveys. They are 'Is your mother alive?' and 'Is

your father alive?'. The idea of obtaining indirect estimates of adult mortality from the proportions of people with parents who have died originated with Henry (1960). Henry's idea was taken up by Brass, who developed a variety of approaches for calculating conventional life table indices from proportions of respondents with living parents, before publishing a straightforward method, expressing the life table measures as weighted averages of two adjoining proportions, that could be applied to both maternal and paternal orphanhood data (Brass and Hill, 1973). Brass's method takes the mean age of parents at the birth of their children as an index of the age at which exposure to the risk of death starts. This is used to select appropriate weights for the conversion of the orphanhood data into indices of survival between convenient specified ages. Thus the measures calculated for women are probabilities of surviving from age 25 to 25 plus the current age of the respondents (l_{25+N}/l_{25} , where N is the central age of the adjoining age groups being averaged). A variety of regression-based procedures for estimating adult female mortality have since been developed, using the Princeton and the new UN model life table systems (eg. UN, 1983; Palloni and Heligman, 1986). These procedures use the same index of the timing of fertility (ie. mean age at childbearing) as the original method and produce equivalent measures of conditional survivorship in adulthood. The difficulties involved in modelling male fertility mean that, to date, the original method proposed by Brass and Hill (1973) remains the only way of analyzing paternal orphanhood data.

Hill and Trussell (1977) suggested an alternative regression-based method of estimation that produces measures of survivorship from birth to a range of adult ages by incorporating an estimate, derived from other questions, of the probability of surviving to age two, among the independent variables. This method was incorporated in the UN (1983) manual on indirect methods and is still often applied. If the level of mortality has been changing, different estimates of survivorship in childhood would be required for each age group. Therefore use of the time location methods developed by Brass and Bangboye (1981) and the methods of deriving complete life tables proposed by Brass (1985) are to be preferred to this approach.

One advantage of the orphanhood method over direct methods of estimating mortality is that the information used is based on the respondent's lifetime

experience. Thus fairly precise estimates of the proportions of respondents with living parents can be obtained from surveys of as few as 5000 individuals. Equally, because the questions involved are simple and can be included on census forms, it is operationally feasible to collect orphanhood data on a very large scale and to use it for detailed studies of mortality in comparatively small districts of a country.

b) Experience and assessment. Collection of orphanhood data in developing countries was initiated by the inclusion of the necessary questions in surveys conducted in Chad and West Cameroon in the mid-1960s. As an UN Adviser, John Blacker was instrumental in getting the questions asked in a number of African censuses and surveys conducted around 1970. Subsequent to the method being espoused by CELADE, orphanhood data were collected in many Latin American countries. The questions were asked in the 12 WFS studies that used the expanded household schedule and are also being asked in many of the Demographic and Health Surveys (DHS) being conducted by Westinghouse for USAID. Thus this type of information on adult mortality is quite widely available and there is considerable experience of its use.

Opinions on the reliability of the orphanhood method as a way of estimating adult mortality have varied over time. After comparing some of the early results with those from other sources, Blacker (1977) concluded that the method was a cheap and simple way of obtaining a rough index of the level of adult mortality that compared well with the available alternatives. Somoza (1981) was of the opinion that the method gave valuable results in four Latin American enquiries. Yet, shortly afterwards, one of the originators of the method was emphasizing its limitations (Hill, 1984b; Zlotnik and Hill, 1981). Recent reviews have taken advantage of the development of techniques for locating the time to which the mortality indices refer and of the increasing availability of several sources of information on adult mortality for the same country. These reviews have been more optimistic (Blacker and Mukiza-Gapere, 1988; Timæus, 1986). Nevertheless, no clear consensus currently exists among demographers on the validity of the orphanhood method and its applications has met with mixed success.

The development of techniques for locating orphanhood-based mortality estimates in time has made interpretation of the findings much easier. While some external evaluations of the validity of the orphanhood method have been

possible, its performance usually has to be assessed on the basis of the internal consistency of two sets of data. In many developing countries successive sets of orphanhood data have indicated consistent levels and trends in adult mortality and agree well with other sources (Moser, 1985; Timæus, in press). In contrast, other countries, such as Kenya and Malawi, offer clear evidence of errors in the data or method of estimation. In particular, the mortality estimates obtained from the reports of young respondents seem too low, exaggerating the apparent decline in the level of mortality.

Two factors probably explain these errors. The first is what is generally termed the 'adoption effect'. Respondents whose parents have died are likely to be reared by another adult and may not even know that this person is not their biological parent. If this foster parent is mistakenly reported on, mortality will be underestimated. The problem is most severe for young children, whose 'adopted' parent may answer the question on their behalf or be assumed by the interviewer to be the real parent. The adoption effect may be more severe for reports about mothers than those about fathers and this could underlie the consistent tendency for African orphanhood data to indicate steeper declines in female than male mortality (Timæus, in press). A second problem with the orphanhood method is the use of mortality models which may incorporate an inappropriate age pattern of mortality (Blacker and Mukiza-Gapere, 1988; Kamara, 1988). This seems to be a particular problem in Africa. While the basic process of estimating conditional survivorship indices (ie. l_{25+N}/l_{25}) is unlikely to be biased greatly by this problem, the conversion of these to a single comparable index of mortality (eg. e_{15}) that can be used to assess trends in the level of mortality over time is more severely affected by the use of an inappropriate mortality model.

Apart from the problem associated with parents who die when their children are very young, questions about orphanhood appear to be well understood by developing country populations and answered accurately. While there is obviously scope for misunderstanding in cultures where the terms 'mother' and 'father' are applied to a broad spectrum of kin, in general the results obtained in censuses have been broadly similar to those obtained in carefully controlled surveys with well trained interviewers. Poor reporting of age is a more prevalent problem and may explain the consistent tendency

for men to report more living parents than women of the same age. Fortunately age exaggeration is more serious for older respondents than for those aged less than 50 whose responses are used to estimate adult mortality from orphanhood data.

An intrinsic problem with the orphanhood method is that most parents are reported on by several children, while no information is obtained at all about people with no surviving children. Biases may arise where there is a relationship between the number of living children and the survival probabilities of their parents. Both theoretical arguments and empirical evidence suggest, however, that the impact of these problems is small (Blacker, 1984; Blacker and Mukiza-Gapere, 1988; Palloni *et al.*, 1984). Attempts to deal with the problem of multiple reporting by asking respondents whether they were their parent's oldest living child proved unsuccessful since far too many people laid claim to this status.

A further, more significant limitation of the method is that it provides estimates of mortality that refer to dates well before the enquiry was conducted. The deaths of parents occur over a period that extends back to when the respondents were born for mothers and about 9 months earlier for fathers. Because the number of parental deaths rises with age, the date at which the mortality of a cohort of parents equals that prevailing in the population is relatively recent, but it is still several years ago. The most recent estimates are based on the reports of the youngest respondents whose responses are most likely to be biased by the adoption effect. Even if information on all age groups is used, the most recent mortality estimates will be for 4 to 5 years before the survey. If the information on respondents aged under 15 is discarded (or not collected as in the DHS), the most recent estimates will refer to a time at least 8 years prior to the enquiry.

2. Combining Successive Sets of Orphanhood Data.

a) Basis and rationale. When two sets of orphanhood data have been collected in successive surveys of the same population, it is possible to derive a single set of proportions orphaned which reflects the level of adult mortality during the period between the enquiries. Unless the two rounds of data collection are separated by a considerable period, this period will be more recent than that on which even the youngest respondents

provide estimates using the straightforward orphanhood method described in the previous section.

An estimation procedure based on the calculation of a synthetic cohort was proposed by Zlotnik and Hill (1981), while Timæus (1986) developed a more flexible approach suggested by Preston and based on a recent generalization of stable population theory. Once an adjusted set of proportions orphaned based on the experience of the inter-survey period has been derived, it can be analyzed by the same methods as those used to calculate measures of conditional survivorship from data collected in a single enquiry. As the estimates derived from respondents of different ages refer to the same period they can be directly compared and their consistency examined. With sufficiently high quality data, inferences can be made about the age pattern of mortality.

One potential problem with this technique of measuring adult mortality, as with any method of estimation based on change between two separate enquiries, is that it is vulnerable to changes in the pattern of reporting errors between the two surveys. As a crude approximation, the sampling error for the difference of two proportions is about 41 per cent larger than the sampling error for either of them considered individually. Moreover, if the quality of the data improves between the enquiries, the level of mortality in the intervening period is likely to be overestimated.

b) Experience and assessment. This is a fairly straightforward extension of the orphanhood method that can be applied whenever data are available from 2 enquiries. It would usually be employed in combination with the basic method. So far it has only been applied in a limited number of countries, though Blacker et al. (1987) have made extensive use of it in their study of district-level differentials in adult mortality in Kenya. The results have not been of sufficient quality to justify inferences about the age pattern of mortality. However, the approach does provide useful information on the extent to which the orphanhood data at young ages are biased downward due to the adoption effect and other problems and, equally, on the extent to which age exaggeration affects the data from older respondents. Unless changing data quality is a major problem, averaging the estimates provided by intermediate age groups will provide a more up-to-date estimate of adult mortality than that obtained from the basic orphanhood method.

3. Questions on the Timing of Parental Deaths.

a) Basis and rationale. Chackiel and Orellana (1985) have proposed that the utility of information about the survival of parents would be increased if a supplementary question was asked about the year in which parents died. With this information one can calculate empirically the mean time at which parents died, rather than using the time location methods first developed by Brass and Bamgboye (1981). Moreover, it is possible to calculate the proportion of respondents whose parents were alive 5 and 10 years before the survey. These data can be analyzed as if three separate enquiries had been conducted at five-yearly intervals using the methods outlined in the previous section. Unlike genuinely independent surveys, such data will not be affected by changes in the quality of the data or by the sampling errors attendant on unmatched surveys.

The main problem with this method is that it requires respondents to accurately remember the interval since their parents died, and thus introduces scope for recall errors. Brass (personal communication) has suggested a simpler question that asks only whether each parent died before or after the respondent married. Aggregate measures of the timing of marriage should be sufficient to estimate the average ages and time over which the parents were exposed.

b) Experience and assessment. Chackiel and Orellana's (1985) paper reports on trials of their approach using maternal orphanhood data collected in two surveys conducted in Latin America. The results seem encouraging. A question on how many years ago parents died was also asked in the survey conducted under the auspices of the DHS in Burundi. Here the major problem was that some 24 per cent of respondents with a dead mother were unable to report how long ago she died, while the same problem was found for 27.5 per cent of dead fathers (C. Makinson, personal communication). The simpler question proposed by Brass was also asked in Burundi and a number of other DHS surveys. Analysis of these data is currently underway.

C. Questions about Widowhood.

1. The basic widowhood method.

a) Basis and rationale. The widowhood method of estimating adult mortality using information about the deaths of first spouses was initially developed by Hill (1977). The expectation was that it would avoid the orphanhood adoption effect and that, except in polygynous societies, biases resulting from multiple reporting would be eliminated. Techniques were developed for estimating male mortality from the reports of female respondents and vice versa. In order to circumvent the difficulty involved in modelling the effects of remarriage of the widowed and divorced, information is only collected on the mortality of first spouses. To maximise the accuracy of the answers, the WFS and other surveys have found it useful to ask explicitly whether the respondent has been married more than once, prior to asking 'Is your first husband (or wife) alive?'.

As with the orphanhood method, Hill's (1977) original technique, which uses a system of weights to adjust for variations in exposure, has been supplemented by regression-based approaches to the estimation of adult mortality from data on widowhood (eg. UN, 1983). In both cases, a series of conditional probabilities of surviving from one age in early adulthood to a range of later ages is obtained by adjusting the proportions widowed on the basis of indices of the average timing of first marriages. There are two possible ways of adjusting for variation in the duration of exposure and the ages over which exposure occurs. One is to tabulate the proportions widowed by marital duration, which yields an exact measure of exposure but requires respondents to remember their ages at marriage accurately. The second is to tabulate the data by the respondents' ages, which may be known more accurately, and to incorporate calculation of an approximate duration of exposure of their spouse into the estimation process. The latter procedure has been used more often and gives good results because in most developing countries first marriages are initiated in a narrow range of ages.

b) Experience and assessment. While questions on the survival of first spouses have been asked in a number of enquiries, the experience gained with this method of measuring adult mortality is far more limited than that available of the orphanhood method. In some surveys the method has given plausible results judged on the basis of consistency with other adult

mortality estimates. In other applications the results have been obviously biased. Thus the method appears to be unreliable. While the orphanhood method sometimes indicates steep declines in mortality which seem implausible, estimates based on the questions about widowhood have often suggested constant or increasing levels of adult mortality. The biases seem to arise in the reported data rather than the estimation process. They can operate in either direction. One problem is that in societies where marriage is ill-defined and more accurately conceived as a process rather than an event, it may be difficult to establish whether a previous union was a marriage. Unions that ended because of the death of a partner may be ignored. On the other hand, where social stigma attaches to divorce, respondents whose unions have broken up may tend to state that they are widowed rather than divorced. More basically, divorced respondents may not know whether their first spouse is still alive. Particular problems can arise with the data on female widowhood in surveys where information on the whole household is provided by the household head. Men appear to be ignorant of, or unwilling to report on, their wives' former marriages (Blacker et al., 1983).

The time-location methods developed by Brass and Bangboye (1981), that estimate the date at which the level of mortality equalled that calculated from the reports of each cohort of respondents, can be applied to widowhood as well as orphanhood data. In theory, the reports of younger respondents yield mortality estimates that refer to the period immediately before the survey. In practice, these data are of little use for the measurement of mortality as the number of deaths that have occurred is very small, owing to the short period of exposure to the risk of death of the spouses, and is subject to random fluctuations. Precise measures can only be obtained from older respondents and the most recent of them still refer to periods several years before the survey.

While the widowhood method of estimation has often performed badly, it would perhaps be premature to abandon it. Now that more is understood about the potential problems, it is possible that better results could be obtained by greater attention to the phrasing of the questions and better training of field staff. It certainly seems desirable that the information should be

collected directly from the individual concerned and not from proxy respondents.

2. Extensions to the Widowhood Method.

Possible extensions to the widowhood method of mortality estimation along the lines of those proposed for the orphanhood method can be envisaged. Since there is a dearth of countries in which two successive sets of widowhood data have been collected there has been little methodological research and no empirical work in this particular area. Analysis of the change in between two enquiries or of information on the timing of the deaths of spouses would be greatly simplified if the data were tabulated by marital duration rather than age. Unfortunately, experience suggests that it is easier to collect data of reasonable quality on ages than dates of marriage. However, this might merely reflect the greater attention devoted to the former question in most surveys.

D. Questions about the Survival of Siblings.

1. The Sibling Survivorship Method.

a) Basis and rationale. A procedure for deriving estimates of adult mortality from the proportion of siblings dead by age of respondent was first described by Hill and Trussell (1977). The necessary information can be gathered during household surveys using straightforward questions on the respondent's number of siblings ever born to the same mother, the number alive at the time of the survey and, thus, the number dead. Separate questions may be asked about male and female siblings to derive estimates of, respectively, male and female adult mortality. These proportions only need trivial adjustment, using weighting factors derived empirically by Hill and Trussell, to yield estimates of life table probabilities of dying. Krishnamoorthy (1979) has been able to demonstrate the analytical relationship between these proportions and life table measures. The key simplification comes from the fact that the difference between the ages of siblings ever born and respondents can be modelled accurately by a symmetrical distribution about a mean zero. The proportion of siblings that have died is approximately equal to the probability of dying by the age of the respondent for respondents aged between about 15 and 50 years.

This method suffers from one of the same problems as the orphanhood method described above. Groups of siblings who have all died are not reported, while the death of one is reported by each of the surviving siblings. If there is a relationship between the number of siblings ever born and their survival probabilities, the estimates will be biased. A further practical drawback to the sibling survivorship method is the possibility that respondents may not know about the existence of siblings who died before the respondents' birth or while they were very young. Such siblings may go completely unreported, thus increasing the apparent proportion of surviving siblings.

b) Experience and assessment. By comparison with the alternative indirect methods for estimating adult mortality, the sibling survivorship technique has received little attention and very limited application. It is therefore difficult to gauge the importance of the problems mentioned above or to dismiss the possibility that more serious difficulties may emerge in a field setting. Ahmed's (1980) survey in North-West Pakistan asked questions about the survival of all first-order relatives, including siblings. For respondents above 30 years, the estimates for adult males and females from the sibling method compared unfavourably with those from the orphanhood and widowhood methods, demonstrating lower levels of survivorship. Ahmed suggests that this may arise from high levels of child mortality in the past to which the siblings of these older respondents were exposed. For the younger respondent age groups, the sibling survivorship estimates appear more reliable, although there is some evidence for under-reporting, relative to male siblings, of both female siblings ever born and the proportions dead. This may be attributable to the difficulties encountered during this survey of a strict Muslim population in eliciting accurate information from female respondents using male interviewers and from male respondents when asked about their sisters.

Questions on sibling survivorship were also included in the Barbados Experimental Migration Study (Somoza *et al.*, 1984; Zaba, 1985) of 1980-81 as part of an attempt to gauge the level of emigration. The reports on the survival of brothers and sisters were felt to be reasonably reliable. The full potential of the sibling survivorship method has clearly yet to be explored. The problems involved in using reports on all the respondents'

brothers and sisters to measure levels of adult mortality suggest that one route to improvement may be through focusing on the survival status of subsets of siblings. A recent development along these lines is the sisterhood method.

2. The Sisterhood Method.

a) Basis and rationale. Combining existing knowledge of fertility and mortality distributions with the basic relationships underlying sibling survivorship, a simple new method has been devised by Graham and Brass (1988). The sisterhood method provides a means of deriving indicators of maternal mortality from the reported proportion of sisters who reached the age of exposure to the risk of pregnancy-related death, and who are alive or have died during pregnancy, childbirth or the puerperium. In addition to the five-year age group of respondents, four basic questions are required:

- How many sisters have you ever had (born to the same mother) who reached the age of 15 (menarche)?
- How many of your sisters who reached age 15 are alive now?
- How many of these sisters are dead?
- How many of these dead sisters died during pregnancy, childbirth, or in the six week (confinement) period after the end of pregnancy?

It can be shown that the proportion of sisters dying of maternal causes reported in a household survey or census by adult respondents is related to the probability of dying of maternal causes by the age of the respondent (Graham and Brass, 1988). The relationship is influenced by the pattern of maternal mortality risks over the reproductive period and the distribution of differences between the ages of siblings and respondents. For respondents in the earlier part of the reproductive period, the reports concern only those sisters who have reached menarche. For respondents aged at least 30, almost all of their sisters will have entered the period of exposure to the risk of a maternal death. The method corrects for incomplete exposure to provide an estimate of the probability of maternal death by the end of the reproductive period or, in other words, the lifetime risk of maternal death. The more conventional measure of maternal mortality - maternal deaths to live births (maternal mortality ratio) - can be derived by a simple

approximation incorporating an estimate of the total fertility rate for the population concerned.

If the number of sisters reported by each age group of respondents is large enough, age-specific estimates of maternal mortality can be calculated by working backwards from the cumulative probability distribution. In addition, variations in lifetime risk between age groups of respondents can be used to give some indication of time trends in maternal mortality. Since the reported deaths will have occurred, on average, longer ago as the age of the respondent increases, a procedure has also been devised for locating the estimates in time. The number of years prior to data collection to which the estimates refer ranges from about 5 years from the reports of respondents aged 15-19 to 35 years for those aged 60-65.

The sisterhood method maximises the number of reported years of risk exposure by asking each adult respondent about all their sisters who reached menarche. One of its major advantages over direct estimation procedures for maternal mortality is the relatively small sample sizes required to produce stable estimates. The method is therefore suited to applications where resources for data collection are limited and the field situation difficult. In these circumstances, the number of respondents, and thus sisters reported, will seldom be adequate for calculating separate estimates from the data supplied by each age group of respondents. By aggregating the information across respondent age groups, a more reliable figure can be produced. For example, accumulating the number of maternal deaths and sister units of risk exposure for all age groups below 50 gives an estimate of lifetime risk for about 12 years prior to the survey.

b) Experience and assessment. The first field trial of the sisterhood method was carried out in The Gambia in 1987 (Graham *et al.*, 1988). Over the course of 5 days, interviews were carried out with 2163 men and women over age 15 living in six rural villages. As this population falls within the Farafenni surveillance area of the British Medical Research Council (MRC), the estimates from the sisterhood method could be compared with those from earlier intensive, prospective studies conducted by the MRC. The lifetime risk of maternal mortality among this rural population was found to be 0.0584 or, in other words, a 1 in 17 chance of death from pregnancy-related causes during the reproductive period. This approximates to a maternal

mortality ratio of 1005 maternal deaths per 100,000 live births and compares favourably with the independent estimates, covering the period 1951-75 for two nearby villages, calculated from the MRC studies, of 1050 and 950.

The number of respondents and thus sisters reported in this trial was the minimum size for deriving a single estimate of lifetime risk in high mortality/high fertility populations. Thus separate measures cannot be calculated by sex of respondent to check internal consistency, or by separate age-groups of respondents to derive age-specific estimates of maternal mortality or to examine time-trends. A more detailed assessment of the field performance of the sisterhood method in The Gambia and in a subsequent trial in Lima, Peru, is given in Graham and Brass (1988). The results from these studies were encouraging and on this basis, a number of developing countries plan to incorporate the questions in forthcoming household surveys, including Bahrain, Bangladesh, Bhutan, Bolivia, Egypt, Ghana, Guinea, Oman, Pakistan and Tanzania.

As a recent addition to the array of indirect methods, the sisterhood method is still at an early stage in its evolution. Additional field investigations and methodological refinements are underway or planned by a team at the London School of Hygiene and Tropical Medicine, including asking simple questions on place and cause of death and applications based on the reports of adults attending fixed health facilities compared to community-based surveys. The major advantage over the basic sibling survivorship method arises from the censoring of the population of sisters to include just those who reached age 15 (menarche) and thus survived the high mortality years of infancy and childhood. Thus a key potential source of bias is reduced since there is unlikely to be a strong association between the number of adult siblings and the probability of maternal death. Moreover, since in the sisterhood method risk exposure is weighted towards the reports of respondents at ages where residence in a nuclear family form, and certainly apart from adult siblings, is most likely, the potential for multiple reporting is reduced. It should also be pointed out that multiple reporting on sisters does not lead to a major bias in the estimates of lifetime risk. Since the analysis is based on a proportional relationship, it can be shown empirically that the number of sisters entering the reproductive period who are counted more than once in the denominator is matched

proportionally by repeat counting of sisters dying of maternal causes in the numerator. The real issue is one of independent observations and thus the sampling variance of the estimates.

IV. POSSIBLE DEVELOPMENTS IN INDIRECT MEASUREMENT.

One area in which there is potential for developing the indirect methods of measuring adult mortality is that of collecting ancillary data which allow the calculation of more age-, time-, and cause-specific measures. At present, research along these lines is focusing on the potential of supplementary questions on the timing of deaths. Both a direct question about this and questions that place the deaths of relatives in relation to some other important life event, such as marriage, are being considered. Methodological work is also being carried out on how to make more accurate inferences about age patterns of mortality (Kamara, 1988). To do so successfully may also require the collection of supplementary data. Although it seems likely that the outcome will be procedures that yield more accurate measures of adult mortality, there is, as yet, little experience of such methods. Numerous issues remain to be answered, both about the questions that should be asked and about methods of analysis.

Experiments with the use of the sisterhood method to measure levels of maternal mortality raise the possibility that indirect methods may provide a basis for collecting data on other causes of death. The information collected from specific close relatives may be more reliable than that obtained on the basis of a question about deaths in the household in the last year. Fewer deaths would go unreported and the variation introduced into the responses by having respondents whose relationship to the deceased can differ, will be eliminated. Ahmed's (1980) study along these lines gave reasonable results, in particular for deaths from accidents and violence. It seems probable that the quality of the information will decline as the interval since the death increases and therefore questions about causes of death should be used in conjunction with one about the time of death. As maternal deaths and accidents can be defined in terms of a contingent period (eg. pregnancy, childbirth, puerperium) or notable event (eg. drowning), rather than on the basis of the investigation of symptoms, they are easier to study retrospectively than other causes. Additional contingent informa-

tion might be useful for identifying certain other causes of death. Considerable attention would need to be given to the wording of the questions. Open-ended questions often perform poorly and it would be important to draw on what has been learnt about the use of symptom-based algorithms to establish causes of childhood death in interview surveys (eg. Garenne and Fontaine, 1986; Zimicki, 1986).

A third possible area of development of indirect methods is to explore the potential of putting questions about the survival of relatives to captive populations such as clinic attenders or children at school. While the respondents are likely to be unrepresentative of the whole population, this may be less true of their relatives. If they prove feasible, such approaches offer the potential to monitor adult mortality by indirect methods on a routine basis as well as by including the questions in population surveys.

CONCLUSIONS.

The level of mortality is clearly an incomplete and distorted indicator of the health of a population. It is, however, of peculiar importance. Inequality in the face of death is perhaps the most appalling of all social disparities and trends in mortality are perhaps the most general pointer to major changes in human welfare. It should also be noted that the operational significance of measures of mortality extends well beyond the health sector. Such measures are an essential input to the process of population projection and thus of making up-to-date population estimates nationally and for smaller administrative areas. Such information is among the most fundamental of requirements for planning in all sectors. Demographic research has repeatedly established that the relative levels of child and adult mortality vary markedly between populations (eg. Ledermann and Breas, 1959). Such differences can extend to neighbouring populations and to different ethnic groups living in the same area (Blacker *et al.*, 1985). It is dangerous to make inferences about the level of adult mortality by extrapolating from information on child deaths. Only genuine measures of adult mortality can serve as a basis for planning.

We have argued elsewhere that the health information systems of many developing countries are in desperate need of rationalization (Graham, 1986; Hill and Graham, 1988; Timæus *et al.*, 1988). In too many countries different ministries and other organizations are engaged in conflicting or duplicating activities. Sophisticated and expensive data collection activities have little point if the information yielded is unreliable, incomplete or covers only a minority of the population. Much of the information that is collected is never processed thoroughly and even less is put to good use in the formulation and administration of health programmes. Often organizations and individuals are so overloaded with demands for statistical information that the quality of the data suffers. We would argue, therefore, that a few reliable indicators, that cover the whole population, are of much more use for health planning than a mass of information of doubtful accuracy and completeness. Developing countries need statistical systems that they have the financial and technical resources to sustain without permanent international assistance.

It is against this background that the measurement of adult mortality must be considered. While better information can help to improve resource allocation, the cost-effectiveness of information systems themselves is also at issue. The different approaches to the measurement of adult mortality that we have considered vary in cost, in the accuracy, detail and timeliness of the information that they can supply, and in their capacity to throw light on causal hypotheses about the determinants of mortality and the impact of interventions. Only a few methods are basically unsound but none of them are fully satisfactory. Thus there is a case for adopting an eclectic approach to trying to improve knowledge about adult mortality in developing countries. Ultimately, assessments of the most appropriate measures and methods should be carried out at a country level and in terms of the existing development of the health and statistical infrastructure and the resources potentially available to the health sector.

In general, rather broad indicators of the level and trend in adult mortality and of differentials between regions and social groups, will serve for the allocation of resources. Studies of socio-economic inequalities in mortality, such as the Registrar General's decennial supplements on occupational and areal differentials in mortality in Britain, complement and

provide a background to more focused studies intended to establish aetiology or to quantify the impact on health of specific behaviours or services (Brass, 1980). Estimates that may be slightly out of date or of moderate accuracy are sufficient for most purposes as only large differences are likely to be of substantive significance (UN, 1984). Most developing countries could reasonably aspire to collect data that are useful for such purposes. Collecting representative information on causes of death in adulthood is far more difficult, but is potentially of great value. The development of improved ways of ascertaining causes of death from lay reports in a range of types of enquiry is an important priority for methodological research. Much more detailed, accurate and timely data are required to evaluate the mortality impact of particular health programmes or medical technologies. Even with such data, it may be difficult to make causal inferences. Information on mortality differentials and trends, in combination with evaluations of programme activity and the results of trials of the efficacy of particular measures, provide a basis for assessing the effect that programmes may have had. More rigorous evaluations of impact will almost always involve specially designed enquiries and this is an important area in which international agencies and research organizations can support the activities of the developing countries.

Vital registration systems represent the traditional source of mortality data in the developed world but the basic rationale for the registration of births and deaths remains administrative rather than statistical. In many countries in Latin America and, to a lesser extent, Asia, registration of adult deaths is nearly complete but the compilation, processing and publication of statistical returns is in disarray. Administrative and financial reforms are needed rather than improvements in methods of measurement. On the other hand, while it would be unwise to consider dismantling an even partially adequate civil registration system, where notification of deaths is very incomplete we seriously question the high priority accorded to civil registration as a source of mortality data. There is no inherent reason why attempts to improve the coverage of the civil registration system need entail attempts to use it as a source of demographic estimates. In countries where only a minority of adult deaths are registered this seems a waste of resources.

There are, nevertheless, major advantages in collecting mortality data on a routine and continuous basis rather than in ad hoc surveys. However, it is debatable whether comprehensive national data is needed for most statistical purposes. Moreover, except for the most basic information required to detect epidemics, chance fluctuations in the numbers of deaths mean that there is little point in trying to analyze data for very small administrative units. Some form of sample enquiry may yield adequate district-level and national measures. Interdisciplinary and organizational divisions have often meant that sample registration and survey based approaches to measuring mortality have developed in isolation from the routine production of statistics by the health services. With existing experience, it is difficult to generalize about whether a more integrated approach would be feasible and beneficial. It would, however, have clear advantages in terms of the possibilities for making useful data available to those involved in planning and managing health services at every level. On the other hand, where coverage by such services is low or there is a flourishing private or traditional health care sector, it may be easier to obtain representative data if their collection is managed independently. Even if a separate statistical system for the collection of mortality data is envisaged, there are clearly major advantages if this can be based on comparable administrative units to those used by the health sector, a consideration that also applies to the estimates generated from censuses.

Whether or not the development of routine systems of providing mortality data is practical, most countries will also need to collect data on adult mortality in censuses and ad hoc surveys. While suffering from its own limitations, such information can contribute to assessments of the accuracy and completeness of that derived from routine sources. Surveys can also provide a richer and more detailed range of information on mortality differentials. Unfortunately, both the WFS and DHS programmes, which have tended to become the models for other sample surveys collecting detailed data relevant to the study of mortality, have had a major interest in contraception and family planning. This has led to the concentration of effort on gathering data about children to the neglect of those concerning adults. We are convinced of the value of including indirect questions about adult mortality in multi-purpose enquiries, such as the census, and of

incorporating investigation of adult mortality into national programmes of household surveys. In contrast only highly specialized and urgent needs, for example, for the study of HIV infection, might justify surveys focused solely on adult health.

Perhaps the most unequivocal conclusion from our review of methods for measuring adult mortality is that questions put to household heads about recent deaths in the household seldom yield useful data and should not be used in their present form. Equally, the main advantage of the indirect methods for the measurement of adult mortality is that they are based on straightforward questions about respondents' lifetime experience that can be posed in single-round enquiries and are efficient in terms of sample size. Questions about orphanhood, in particular, offer the possibility of obtaining useful information fairly cheaply. They can be used even in countries which lack an effective means of collecting information on adult mortality rates in the population on a routine basis. The main limitation of these methods is that they provide rather broad and non-specific measures of mortality. While methods have been posited that may make it possible to obtain more specific data on ages, dates and causes of death, they remain experimental and certainly could not be recommended for widespread application without further developmental effort.

In summary, in the large number of developing countries where complete registration of deaths remains a distant and questionable goal, the combination of sample routine health reporting systems and the inclusion of indirect questions in single-round surveys may provide the best way of trying to collect data on adult mortality to inform health planning. The estimates that result from these approaches fall a long way short of the ideal proposed in the introduction to this paper, namely obtaining mortality rates by age and cause for sub-groups of the population. Arguably this does not matter. There are very few countries in which health planning is such a sophisticated process that it can use refined and precise measures to greater effect than broad indications of mortality patterns. Demographic research has shown that the similarity of age patterns of mortality in all populations means that it is possible to estimate mortality rates with reasonable reliability from simple data on the proportions of surviving relatives of respondents. Further development of these methods may lead to

techniques for obtaining more specific measures of adult mortality. In addition, methodological research is needed to examine whether indices of mortality by cause can be inferred from rather general measures of proportions dying from particular causes in a comparable way. Finally, it is also important to investigate whether there is scope for collecting further information needed for health planning in the context of survey investigations designed to measure levels, trends and differentials in adult mortality. In particular, could the indirect questions employed in single-round surveys be extended to investigate causes of death, on the one hand, and some of the social and economic consequences of adult deaths, on the other? Moreover, could the measurement of adult mortality be usefully integrated with efforts to fill the significant gaps that exist in our understanding of ill-health in the surviving adult population?

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